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EFFECTS OF SILVICULTURAL TREATMENTS AND ENVIRONMENTAL FACTORS ON WOOD PROPERTIES OF SOUTHERN PINES[1]

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ABSTRACT: Growth and yield models should predict not only the volume of wood produced but also properties and value of wood produced. The influence of species, planting density, periodic thinning, and geographic location on juvenile wood formation and lumber grade yield are examined. Initial planting density, thinning regime, geographic location, and rotation length can be used to predict wood properties.

INTRODUCTION

People's ideas about the management of public forest lands are changing. Many people now assign higher priorities to the protection of endangered species, wildlife management, and recreation opportunities than to production of forest commodities. These changes are leading to significant reductions in timber harvesting in the West. The South, with its large potential for timber production, will have to produce an increasing share of the domestic supply of softwood timber. Recent surveys indicate the South's natural softwood stands are rapidly being replaced by pine plantations (USDA Forest Service, 1988). From 1977 to 1985, the area of natural pine timberland in the South in natural pine decreased 18 percent while the area in planted pine increased 41 percent. It is projected that the timberland area in planted pine will double and that the area in natural pine will be reduced by one-half in the 12 southern states by the year 2030 (Alig and others 1986).

The physical and mechanical properties of wood from fast-growing plantations are often inferior to those of wood from older, natural stands. The two wood properties that most influence the desirability of plantation wood are juvenile wood and the size and frequency of knots. Juvenile wood and large knots weaken building products and make them more prone to warp, creating problems for manufacturers and consumers alike. Proper silvicultural practices can result in the production of plantation wood that will meet quality requirements in the market place. Growth and yield models should predict not only the volume of wood produced but also the properties and value of the wood produced. This paper reviews the effects of silvicultural practices and environmental factors on juvenile wood formation and lumber grade yield and value.

LITERATURE REVIEW

A radial cross-section of a pine stem contains three zones of wood: 1) core or crown-formed wood produced by immature cambium in the vigorous crown, which has anatomical, chemical, and physical properties substantially different from those of mature wood; 2) transition wood, a zone in which wood properties are changing rapidly before wood matures fully, and 3) mature wood. As trees grow older and taller and stands close, lower branches cease to be vigorous and the lower limit of active crown moves up the stem. Therefore, there is a core of crown-formed wood surrounded by a

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band of transition wood from the butt to the merchantable top of the tree (Paul 1957, Zobel and others 1959). Both crown-formed and transition wood are commonly referred to as juvenile wood.

The properties of juvenile wood and their adverse effects on product quality and yield have been reported by many researchers (Thomas 1984, Megraw 1985, Zobel 1981, Bendtsen 1978, Bendtsen 1987, Senft and others 1986). Tracheids in crown-formed wood are shorter and thinner walled with larger lumens than are mature-wood tracheids, and crown-formed wood contains a smaller proportion of latewood tracheids than does wood formed below the crown. The proportions of earlywood and latewood are the major determinants of specific gravity, and the specific gravity of mature wood is 15 to 30 percent greater than that of juvenile wood. Because wood from young fast-growing plantations contains a high proportion of juvenile wood, it yields less pulp per green ton than does wood containing a lower proportion of juvenile wood.

A recent study of the influence of juvenile wood on grade yield of veneer (MacPeak and others 1987) showed that fast-growing plantation loblolly pines 20 to 25 years old yield substantially less veneer and veneer of lower grade than do slower-grown trees of similar size. Recent studies of the influence of juvenile wood on the strength of dimension lumber (MacPeak and others 1990, Pearson 1988, McAlister and Clark 1991) show that some lumber cut from the juvenile zone of young fast-grown plantation pine may not meet design requirements.

JUVENILE WOOD FORMATION

The literature indicates that duration of the period of juvenility differs among species. For example, slash pine is reported to have a juvenility period of 6 to 8 years and loblolly a juvenility period of 9 to 12 years (Larson 1969, Pearson and Gilmore 1980, Taras 1965). However, a recent study by Clark and Saucier (1989) shows that duration of the juvenility period in slash and loblolly is less influenced by species than by environmental differences associated with geographic location. Clark and Saucier sampled the two species growing together in the same or neighboring plantations at four locations from the Piedmont of South Carolina to the Gulf Coastal Plain of Florida. At each location, the duration of juvenility was similar for the two species, but the length of the juvenile period differed from location to location.

The duration of juvenility in planted loblolly and slash pine is not influenced by initial spacing, but the diameter of the juvenile core is significantly correlated with initial spacing (Clark and Saucier 1989). Plots of average 2-year specific gravity data over rings from pith for 6 by 6-, 8 by 8-, 10 by 10-, and 15 by 15-foot spacings showed that slash pine in the Upper Coastal Plain of Georgia produced juvenile wood for the first 10 rings at all spacings sampled. Wood produced after the 10th year at each spacing had mature wood characteristics. The diameter of the juvenile wood zone was significantly related to initial spacing and averaged 4.0 inches in trees spaced 6 by 6 feet, 4.6 inches in trees spaced 8 by 8 feet, 5.5 inches in trees spaced 10 by 10 feet, and 6.3 inches in trees spaced 15 by 15 feet.

Loblolly pine planted at 6 by 6-, 8 by 8-, 10 by 10-, and 12 by 12-foot spacings in the Piedmont of Georgia has a longer and more gradual juvenile transition period than slash pine sampled in the Upper Coastal Plain of Georgia (Clark and Saucier 1989). The loblolly pine produced juvenile wood up to and including the 14th ring at each spacing, and then produced mature wood. The diameter of the juvenile wood zone in loblolly averaged 5.2 inches in trees spaced 6 by 6 feet, 6.0 inches in trees spaced 8 by 8 feet, 6.6 inches in trees spaced 10 by 10 feet, and 7.7 inches in trees spaced 12 by 12 feet.

The influence of geographic location on length of juvenility was also described by Clark and Saucier (1989). Plotting loblolly specific gravity over rings from pith yielded two groups of curves--one for the Piedmont locations and one for the Coastal Plain locations. Loblolly pine in the Coastal Plain produced juvenile wood for the first 6 to 10 rings, while loblolly pine in the Piedmont produced juvenile wood for the first 10 to 14 rings.

The duration of juvenility in slash pine also varied by geographic location (Clark and Saucier 1989). Slash pine produced juvenile wood for the first 6 years in Florida, the first 10 to 12 years in the Coastal Plain of South Carolina and Georgia, and the first 14 years in the Piedmont of South Carolina.

The variation in duration of juvenility by geographic location appears to be related to length of growing season and seasonal rainfall patterns. Zahner (1963) hypothesized that when soil moisture is plentiful cell division and maturation are rapid and there is severe competition for carbohydrates and auxins among newly formed cells. Under these conditions the cambium is better able to compete for these materials than are maturing tracheids. Thus, the maturing tracheids die and become part of the earlywood. When soil moisture is scarce and moisture stress high, cambial activity is reduced, maturing tracheids can compete more successfully for available carbohydrates, wall thickening occurs, and latewood is produced.

LUMBER GRADE YIELD

Thinning and control of initial planting density are silvicultural tools that can be used to control proportion of basal area in juvenile wood, size and number of knots, and thus the quality of lumber produced from plantation trees. Consider the results of a study in which planted 38-year-old loblolly pines grown on the Gulf Coastal Plain of Louisiana were sawn into lumber (Clark and others 1991). The trees were planted on five spacings: 6 by 6, 8 by 8, 9 by 9, 10 by 10, and 12 by 12 feet. At ages 18, 23, 28, 33, and 38, plots of trees planted at each spacing were thinned to basal areas of 60, 80, 100, and 120 ft^2 per acre and were then maintained at those basal areas. At age 38, trees were harvested and processed into lumber. Trees were harvested from unthinned 6 by 6-, 9 by 9-, and 12 by 12-foot plots. Sawlogs $\geq$ 10 inches scaling diameter were processed at a band mill and logs < 10.0 inches scaling diameter processed at a chipping-saw-mill. Lumber cut from each log was identified, dried, and graded after planing. The trees harvested produced juvenile wood for an average of 10 rings from the pith.

The effect of thinning for basal area maintenance after age 18 on the percentage of lumber classed as juvenile wood is shown in figure 1. Stands planted at 6 by 6- or 9 by 9-foot spacings and thinned after age 18 produced a lower percentage of lumber classed as juvenile wood than did stands planted at 12 by 12 feet. For example, trees from stands maintained at 60 ft^2 basal area yielded 31 percent juvenile wood lumber in stands initially planted 6 by 6 feet, 35 percent in those planted at 9 by 9 feet and 39 percent in those planted at 12 by 12 feet. Forty-five percent of the lumber obtained from the 12 by 12-foot unthinned stands was classed as juvenile wood.

Initial spacing and thinning to different residual basal areas after age 18 had substantial effects on the proportion of lumber graded number 2 and better (fig. 2). Thinning after age 18 generally increased lumber grade for the 6 by 6- and 9 by 9-foot initial spacings. The most heavily thinned 6 by 6- and 9 by 9-foot stands produced the highest proportion of number 2 and better lumber. However, heavier thinning significantly reduced the proportion of lumber graded number 2 and better in plots planted at a 12 by 12-foot spacing.

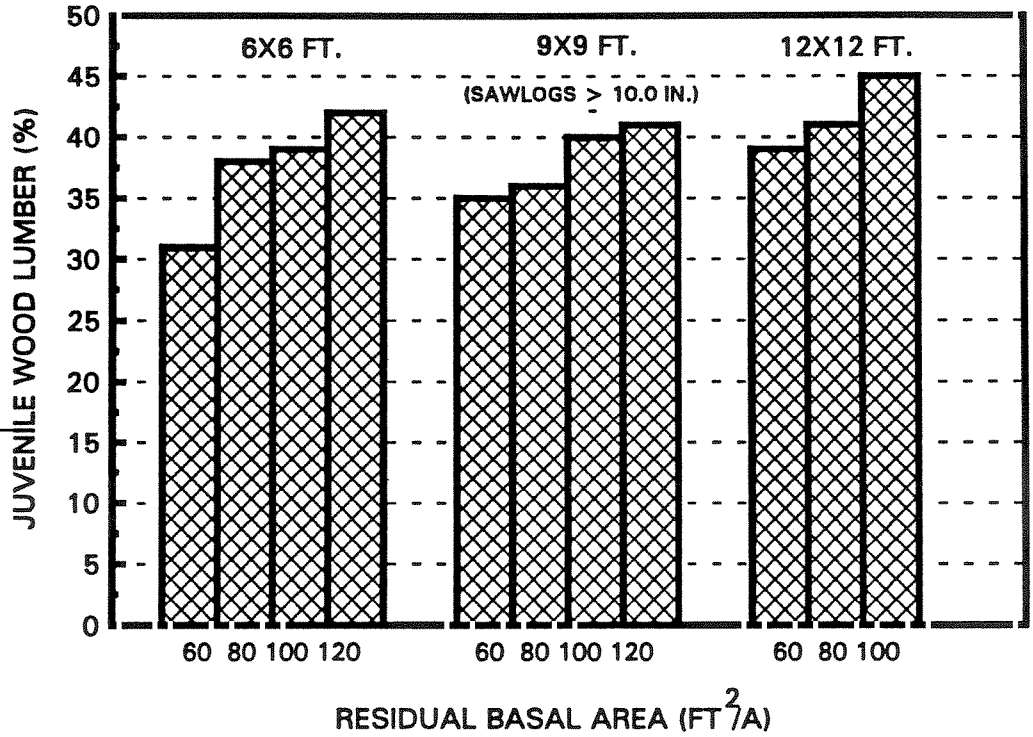

Figure 1.--Effect of initial spacing and thinning to residual basal areas after age 18 on percentage of lumber classed as juvenile wood for loblolly pine in the Gulf Coastal Plain.

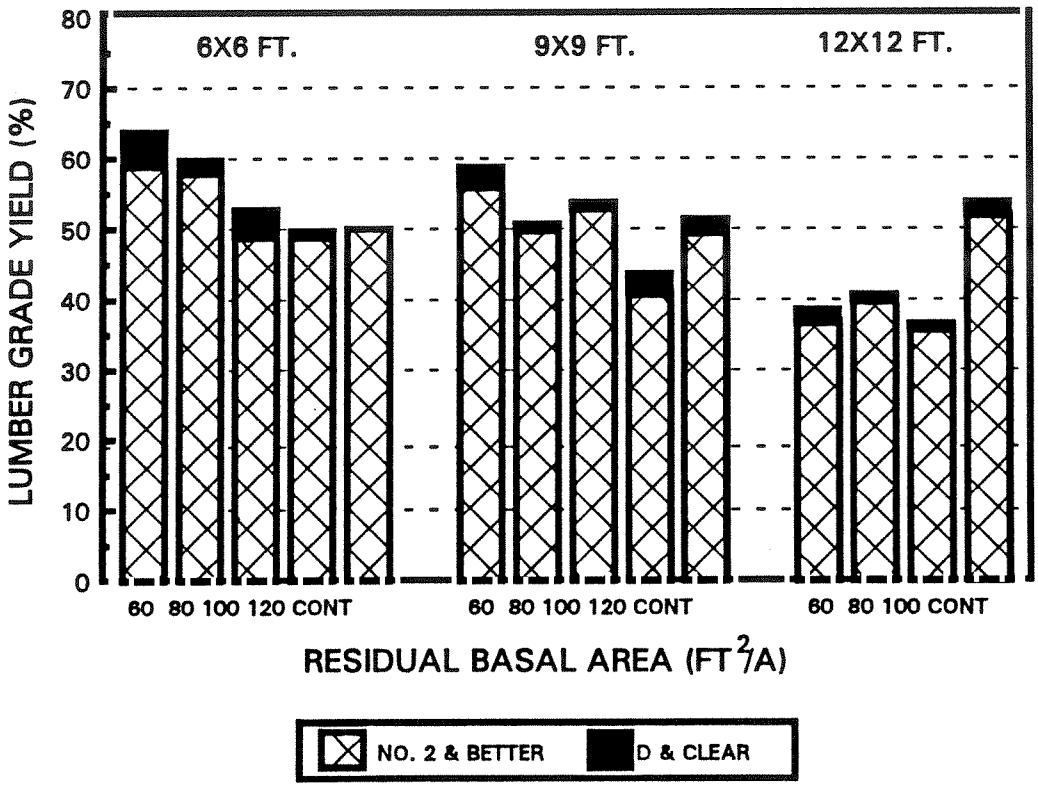

Figure 2.--Effect of initial spacing and thinning to residual basal areas after age 18 on percentage of lumber graded No. 2 and better for loblolly pine in the Gulf Coastal Plain.

These differences in lumber grade yield occur because the trees planted at the relatively close spacings produce thinner branches and prune earlier than do trees planted at the 12 by 12 spacing. After thinning, trees initially planted at close spacings produce clear mature wood along the lower bole, but trees in the thinned 12 by 12-foot stands have persistent lower branches that continue to increase in size, give rise to large knots, and reduce lumber grade yield.

The results of lumber yield studies reported by MacPeak and others (1990) and by Biblis (1990) illustrate the importance of controlling branch size and juvenile wood content by regulating initial spacing and thinning. In the MacPeak and others study, lumber cut from 20-year-old slash pine planted 12 by 12 feet and thinned to 250 trees per acre was compared to lumber cut from 50-year-old slash pine planted 6 by 6 feet and thinned at ages 12, 20, 25, and 35 to a final density of 245 trees per acre. The 20-year-old trees averaged 14.3 inches d.b.h. and the 50-year-old trees 15.1 inches d.b.h. Only 38 percent of the lumber cut from the 20-year-old trees was graded No. 2 and better, but 69 percent of the lumber cut from the 50-year-old trees was graded No. 2 and better. All lumber cut from the 50-year-old trees complied with the Southern Pine Inspection Bureau (SPIB 1977) MOE structural requirements for its visual grade but only 14 percent of the lumber cut from the 20-year-old trees met SPIB structural requirements. However, 92 percent of the dimension lumber cut from a 27-year-old slash pine plantation (Biblis 1990) planted 6 by 6 feet and thinned only slightly at age 15 was No. 2 or better, and 88 percent of the lumber produced met the SPIB MOE structural requirements for its visual grade.

The importance of growing quality wood becomes even more apparent when the lumber is valued by grade and volume using current wholesale lumber prices. Figure 3 shows the effect of thinning to residual basal area after age 18 on the value per thousand board feet (MBF) of lumber produced from trees grown at 6 by 6-, 9 by 9-, and 12 by 12-foot initial spacings. Figure 3 was developed assuming that clear and D 4/4 lumber

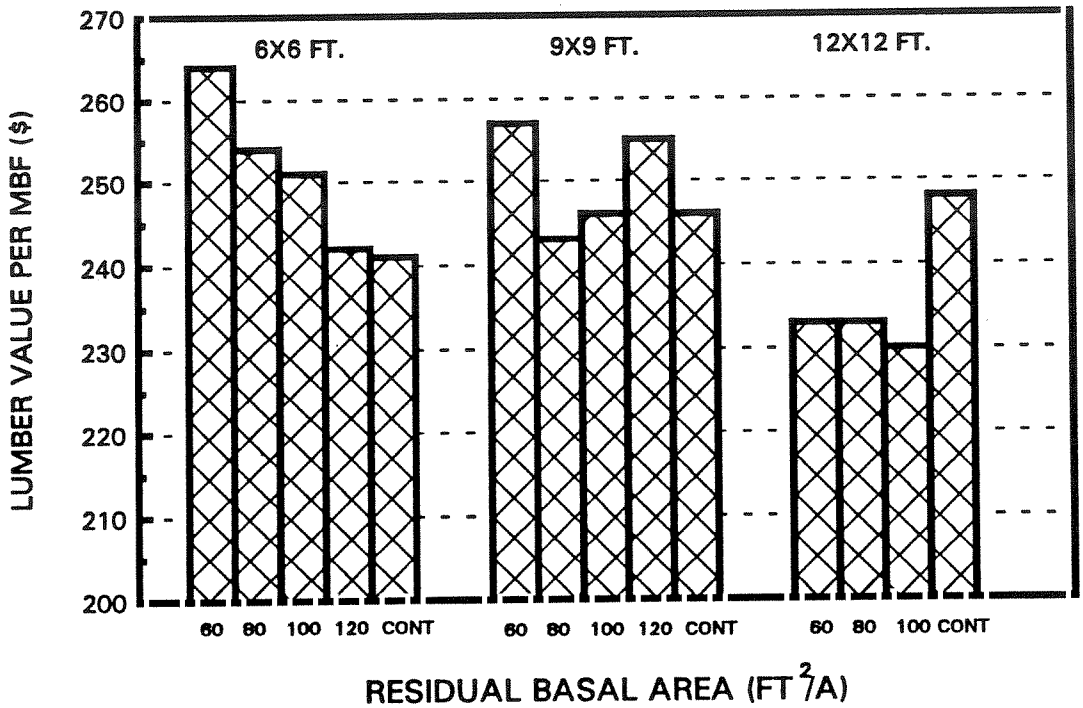

Figure 3.--Effect of initial spacing and thinning to residual basal areas after age 18 on value of lumber per MBF for loblolly pine in the Gulf Coastal Plain.

is valued at $500/MBF, that No. 2 and better 8/4 lumber is valued at $290/MBF, and that No. 3 and No. 4 8/4 lumber is valued at $190/MBF. Planting at initial spacings of 6 by 6 or 9 by 9 feet and then thinning to residual basal areas after age 18 generally yielded lumber of increased value, while planting at a spacing of 12 by 12 and then thinning resulted in a substantial reduction in lumber value. For example, the trees planted at 6 by 6- and 9 by 9-foot spacings and then thinned to 60 ft^2 basal area yielded lumber valued at 13 and 10 percent more per MBF than the lumber cut from the 12 by 12-foot plots thinned to 60 ft per acre.

CONCLUSION

Predicting wood properties will become increasingly important as the volume of high quality lumber produced in natural stands continues to decline. Plantations will have to be managed to capture the price differential between No. 2 and better lumber and No. 3 and shop lumber.

When growth and yield models for planted southern pine are developed it is important that the models account for not only changes in wood volume but also changes in wood properties. Results of the studies summarized here indicate three variables or silvicultural tools that can be used to influence wood properties. These variables are: 1) initial planting density, 2) thinning regime (thinning to a given residual basal area after a minimum age), and 3) length of rotation. Although initial planting density does not influence duration of juvenility it can be used to control the diameter of the juvenile wood core, control branch size, and stimulate branch pruning. Thinning for basal area control after a minimum age results in production of clear mature wood along the lower stem. The minimum age at which thinning should be performed is related to initial planting density and site index, and is also related to geographic location since length of juvenility period increases from coastal to inland regions. Rotation length and stand density control are also important because they determine the volume of clear mature wood produced along the bole.

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